Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.4, No.1, 2014
www.iiste.org

Investigation of Groundwater Pollution in Selected Areas of Uromi, Esan North East Localgovernment Area, Edo State, Nigeria

Biose Osadebe[1,2], Omamoke O. E. Enaroseha[3,4].
1.National Centre for Energy and Environment (Energy Commission of Nigeria), Benin City, Nigeria
2.Department of Physics, University of Benin, Benin City, Nigeria
3.Nigeria Atomic Energy Commission, Abuja, Nigeria
4.Center for Nuclear Energy Studies, Port – Harcourt, Nigeria
bosadebe@yahoo.com, enarosehaomamoke@gmail.com;

Abstract
We investigation groundwater pollution in Ivue, Idumoza, Egbele, beside Zaki's palace Eguare and Uje-oro Eguare in Esan North East Local Government Area of Edo State, Nigeria. The SAS 300B ABEM Terrameter was utilized for data acquisition using the Schlumberger electrode configuration and IP2Win computer iteration programmes for data interpretation. We also investigate the chemical properties for the hand dug well in the area. The selected chemical Properties examined where pH, TDS, TSS, conductivity, Hardness, Turbidity, Colour, Alkalinity, Iron, Zinc, Manganese, Copper and Nitrogen Oxide. The experimental results obtained in the area under study show a depth of 36.90 meters, 37.10meters, 92.60meters, 69.01meters and 15.93meters respectively. At a maximum penetration of 69.01meters, a perched aquifer was encountered. Groundwater samples taken from hand dug wells were subjected to physical and chemical analyses. The results of the laboratory analyses revealed evidence of pollution from physical and chemical sources. These were evidence from high nitrate in Egbele (3.20mg/L), beside Zaki's palace (4.44mg/L) and low pH in Uje-oro in Eguare (5.86) which were not within the ecological benchmark of (0.3mg/L) and (6.5-8.5) recommended by the WHO drinking water standard respectively. It was established that wells were polluted in areas nearer to farmlands than areas further away from them due to high concentration of Nitrogen Oxide based fertilizers used by farmers. To mitigate the high level of Nitrate and pH concentration in boreholes and hand dug wells to fall within the acceptable limits of WHO drinking water standards, pH correction (addition of sodium carbonate) and boreholes / hand dug wells should be sited far away from the farm lands were Nitrogen based fertilizers are used and also sanitation units.

1.0 INTRODUCTION

The city of Uromi lies north-eastern Esan in Edo State, Nigeria, located on longitude 3° 24' E and latitude 6° 27' N. Almost the whole of the city is covered with land (Okoduwa, 2007). The people of Esan occupy a land mass covering about 2987.52 square kilometres (Omo-Ojugo, 2004). The people of Uromi are known for farming and trading whilst the government's budget contributes to the individual resources. Its high and good farm output is greatly encouraged by the vegetation zone which is a rain forest zone, soil type (loamy). It also has a good numbers of markets that provides the opportunities to the local farmers to commerce their farm products (Osagie, 2007). Uromi is made up of twenty villages and they are located approximately on a landmass of not more than 60 square miles. These villages are Amedeokhian, Arue, Awo, Ebhoiyi, Efandion, Egbele, Eguare, Ekhue, Eror, Idumoza, Ivue, Obeidu, Onewa, Oyomon, Ubierumu Ne-uwa, Ubierumu Ne-oke, Ukoni, Unuwazi, Utako and Uwalo (Osagie, 2007). Among the Esan plateau dwellers, Uromi stands topmost on the plateau sitting at about 304800mm above sea level, (Butcher, 1982) with the village of Ivue occupying the highest point on the Ishan plateau with about 454150mm above sea level (Okojie, 1994,).

Water pollution is a major problem in the global context, and it has been suggested that it is the leading worldwide cause of deaths and diseases (World Resources, 1998). Human activities during the last century have polluted most of the groundwater in Nigeria (Osibanjo 1994). Water is the most studied material on earth but its remarkable to find that its behaviour and function are so poorly understood and at times even ignored, not only by people in general, but also by scientists working with it every day. Although we drink it, wash, fish and swim in it and even cook with it, we nearly always overlook the special relationship it has with our lives (Sandi and Darrin, 2007). Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions. Most of the population of Esanland use water from different sources. The most dependable source however is the underground storage tank which is referred to as 'artificial' or 'Hand dug' well in the study area. These are found in every house and over 95 percent of the people depend on them for water supply during rainy season while about 78 percent depend on them during the dry season (Okhae, 2005). It is the purpose of this paper to evaluate the water quality of the study area and define zones of potential groundwater contamination.

METHODOLOGY

In this research work, the Schlumberger array in electrical resistivity survey was adopted. The basic field equipment for this study is the ABEM Terrameter Self Averaging Signal (SAS) 300B which displays apparent resistivity values digitally as computed from ohm's law. It is powered by a 12.5 V DC power source. Other accessories to the terrameter includes the booster, four metal electrodes, cables for current and potential electrodes, harmers, measuring tapes and cutlass. In this configuration, the four electrodes are positioned symmetrically along a straight line, the current electrodes on the outside and the potential electrodes on the inside. To change the depth range of the measurements, the current electrodes are displaced outwards while the potential electrodes in general, are left at the same position (Osemeikhain *et al.,* 1994).

When the ratio of the distance between the current electrodes to that between the potential electrodes becomes too large, the potential electrodes must also be displaced outwards otherwise the potential difference becomes too small to be measured with sufficient accuracy (Koefoed, 1979). For the purpose of this survey, a maximum spread of AB/2 equals 316.00meters was used. One of the major advantages of this method over other methods is that only the current electrodes need to be shifted to new position for most readings while potential electrodes are kept constant for up to three or four readings (Reinhard, 1974). During the field work, taking a sounding, the ABEM Terrameter SAS 300B (Self Averaging System) performs automatic recording of both voltage and current, stacks the results, computes the resistance in real time and digitally displays it. (Dobrin and King,1976). The etrex Legend H of the global positioning system (GPS) was used to map out various vertical electrical sounding (VES) stations in the area under investigation. Groundwater samples were collected from hand dug wells and were analysed in Edo Environmental Consults and Laboratory, Ministry of Environment and Public Utilities, Palm House Annex, Sapele Road, Benin City and the data obtained were compared with the World Health Organisation (WHO) standards of drinking water (WHO, 2006). The chemical characteristics include pH, Total Dissolve Solids (TDS), Conductivity, Total Suspended Solids (TSS), Hardness, Turbidity, Colour, Alkalinity, Iron, (Fe), Zinc (Zn), Manganese (Mn), Copper (Cu), and Nitrogen Oxide (NO_2). Their concentrations were established using standard laboratory procedures; pH meter, EC meter, TDS meter, Turbidity meter, Titrometric method, Atomic Absorption spectrophotometer, UV spectrophotometer.

RESULTS AND DISCUSSION

The results of the geophysical survey employing the techniques of vertical electrical sounding (VES) are presented as field/computer iterated curves shown in Fig. 1 to Fig. 5, the test parameters of physiochemical properties are shown in Table 1.1 and their corresponding subsurface lithological tables shown in Table 2.1 to Table 6.1. The results of each location are presented below with a view of determining the presence of aquifer, soil lithology, total depth of penetration of current and evaluation of water quality.

Table 1.1: Values of Physical and Chemical properties of hand dug well water sample in the Study area.

Location of Hand dug well	**pH**	**(EC) ($\mu s/cm$)**	**TDS (Mg/l)**	**TSS (Mg/l)**	**Hardness (Mg/l $CaCO_3$)**	**Turbidity (FAU)**	**Colour (ptCo)**	**Alkalinity (Mg/l $CaCO_3$)**	**(Fe) (Mg/l)**	**Zn (Mg/l)**	**Mn (Mg/l)**	**Cu (Mg/l)**	**NO_2 (Mg/l)**
Ivue	6.58	22.4	14.9	Nil	2.06	1	1	57	ND	0.11	ND	ND	Nil
Idumoza	6.65	24.0	16.1	Nil	1.35	1	2	35	ND	0.16	ND	ND	Nil
Egbele	6.79	33.8	29.3	Nil	1.56	5	2	68	ND	0.09	ND	ND	3.20
Zaki's palace Eguare	6.80	80.5	57.1	Nil	2.69	2	2	73	ND	0.21	0.02	ND	4.44
Uje-Oro, Eguare	5.61	115.7	81.9	Nil	4.44	4	1	64	ND	0.06	ND	ND	Nil
WHO Standards	**6.5-8.5**	**1000**	**1000**	**N/A**	**100-500**	**5**	**15**	**500**	**1**	**5**	**200**	**0.03**	**0.3**

FAU = Formazin Attenuation Units, $\mu s/cm$ = Micro second per centimetre, **Mg/l** = Milligram per litre, **ptCO** = Platinum-Cobalt Scale.

Computer iterated curves are shown in Fig. 2.1 to Fig. 6.1 and the corresponding subsurface lithological tables are shown in Tables 2.1 to Fig 6.1.

Table 2.1: Lithology for Ukpulegbe (Ivue), Uromi

Layer	Apparent Resistivity ρ_a (Ohm-m)	Thickness h (m)	Soil Lithology
1.	4718	15.5	Top soil
2.	147	21.4	Clayey Soil
3.	386692	∞	Dry Sand

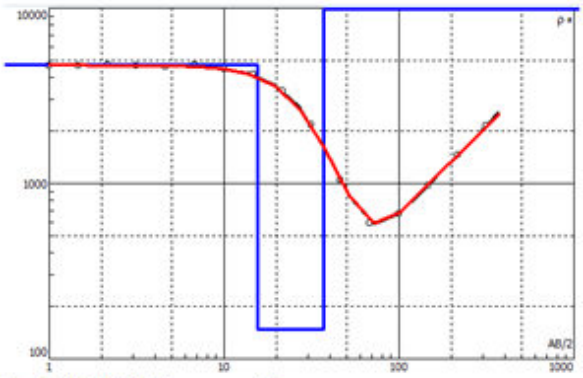

Fig. 2.1 :VES Curves and Layers Resistivity for Ukpulegbe (Ivue)

Total Depth = 36.9 meters

The survey was carried out in Ukpulegbe (Ivue), Uromi, with a GPS Co-ordinate of N06^0 44.363' E006^{0}16.495'. The result shows a three-layer QHK-type geoelectric structure. Layers 1-3 have resistivity values of 4718 ohm-m, 147 ohm-m and 386692 ohm-m respectively. Layers 1 and 2 have thickness 15.5m and 21.4m respectively. The top layer is composed of top soil, the second layer contain clayey soil while the last layer have dry sand. The total depth of the survey area is 36.9 meters. No evidence of aquifer here.

The physiochemical analyses of well water sample carried out in Ivue, Uromi shows that all the parameters analysed for groundwater were within the desirable limits of the WHO standards of drinking water (See Table 1).

Table 3.1: Lithology for Idumoza Road, Uromi

Layer	Apparent Resistivity ρ_a (Ohm-m)	Thickness h (m)	Soil Lithology
1.	1258	14.8	Top Soil
2.	613	22.3	Clay
3.	294196	∞	Dry sand

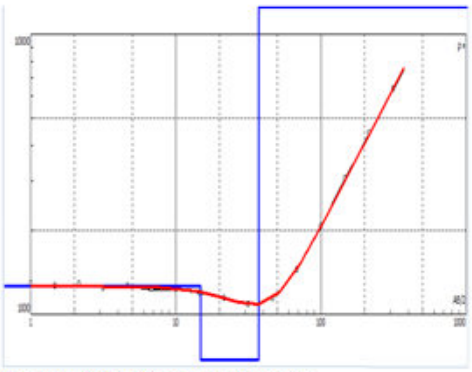

Fig. 3.1: VES Curves and Layers Resistivity for Idumoza Road

Total Depth = 37.1 meters

The survey was carried out in Idumoza Road, Uromi, with a GPS Co-ordinate of N06^0 43.818'E006^0 17.915'. The results obtained show a three-layer QH-type geoelectric structure. Layers 1, 2 and 3 have resistivity values of 1258 ohm-m, 613 ohm-m and 294196 ohm-m respectively. Layer one of thickness 14.8m is top soil, layer two with thickness 22.3m contains clay while layer three has dry sand. The total depth of penetration is 37.1 meters. Water was not encountered in this station.

The physiochemical analyses of well water sample carried out in Idumoza, Uromi shows that all the parameters analysed for groundwater were within the WHO standards of drinking water (See Table 1).

Fig. 4.1: Lithology for Odogbe Street, EgbeleUromi

Layer	Apparent Resistivity ρ_a (Ohm-m)	Thickness h (m)	Soil Lithology
1.	2103	38.8	Top soil
2.	398	53.8	Sand stone
3.	157194	∞	Dry sand

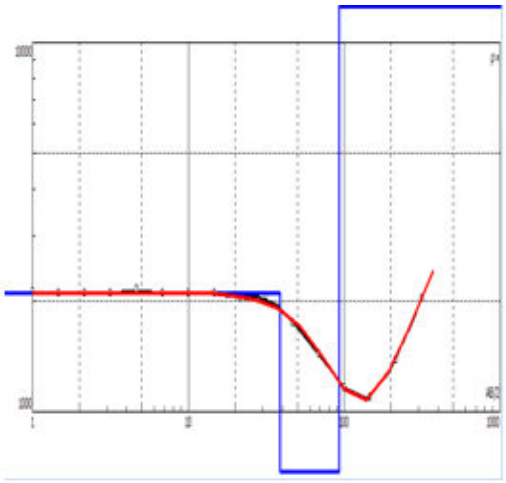

Fig. 4.1: VES Curves and Layers Resistivity for Odogbe Street, Uromi.

Total Depth = 92.6 meters

The sounding was carried out in Odogbe Street, Egbele, Uromi, with a GPS Co-ordinate of $N06^0$ 43.768' $E006^0$ 18.802'. The result indicates a three-layer curve. Layers 1 – 3 have resistivity values of 2103 ohm-m, 398 ohm-m and 157194 ohm-m respectively. Layers 1 and 2 have thickness 38.8m and 53.8m respectively. The top most layer is composed of top soil, layer two has sand stone while layer three have dry sand. The total depth of the survey area is 92.6 meters. No evidence of aquifer in this station.

The physiochemical analysis of well water sample carried out in Egbele, Uromi shows that all the parameters of the groundwater analysed were within the WHO standards of drinking water (see table 1) except for NO_2 (nitrite) 3.20mg/L which was above the WHO drinking water standards of 0.3mg/L. It was observed that the location where the well water samples were collected were close to farmlands in which nitrogen based fertilizers were used due to intense farming in the area, thereby leading to high NO_2 concentration in groundwater. When there is excessive rainfall nitrate will be leached below the plants roots zone and may eventually reach groundwater. Nitrate is highly leachable and readily moves with water through the soil profile. NO_2 in drinking water can be hazardous to health especially for infants (blue baby syndrome). Symptoms include shortness of breath and blueness of the skin.

Table 5.1: Lithology for Orahieralen, Beside Zaki's Palace, Eguare, Uromi

Layer	Apparent Resistivity ρ_a (Ohm-m)	Thickness h (m)	Soil Lithology
1.	1228	0.588	Top soil
2.	6533	0.522	Sand stone
3.	393	10.9	Clay
4.	5609	57	Sand stone
5.	1150	∞	Perched aquifer, i.e small water-bearing sand

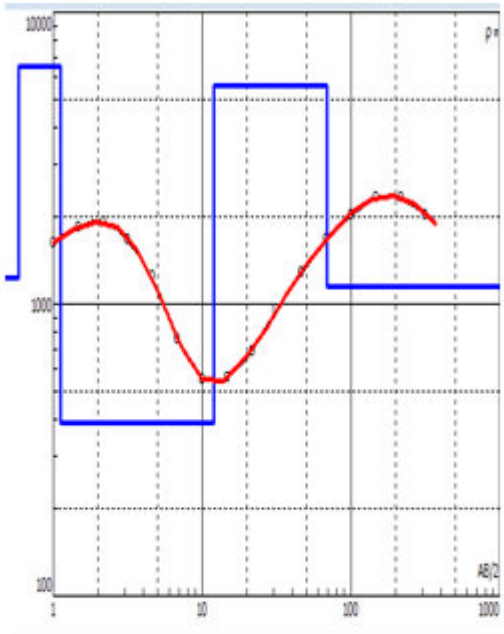

Fig. 5.1: VES Curves and Layers Resistivity for Orahieralen, beside Zaki'sPalce, Eguare, Uromi

Total Depth = 69.01 meters

The survey was carried out in Orahieralen, beside Zaki's Palace, Eguare, Uromi, with a GPS Co-ordinate of $N06^0$ 43.217' $E006^0$ 19.759'. The results obtained from the sounding shows a five-layer geoelectric structure with a QHK-type curve. Layers 1 – 5 have resistivity values of 1228 ohm-m, 6533 ohm-m, 393 ohm-m, 5609 ohm-m and 1150 ohm-m respectively. The first layer of thickness 0.588m is made up of top soil, layer 2, 3 and 4 of thickness 0.522m, 10.9m and 57m respectively are made up of sand stone, clay and sand stone respectively, while the fifth layer contains perched aquifer, that is, small water bearing sand. The maximum depth penetrated is 69.01 meters. A small aquifer was encountered here.

The physiochemical analyses of well water sample carried out in Eguare, Uromi, shows that the parameters analysed for the groundwater collected were within the desirable limits of the WHO standards of drinking water (see Table 1) except for NO_2 (nitrite) 4.44mg/L which was above the WHO drinking water standards of 0.3mg/L. We also observed that in Odogbe Street, Egbele and Orahieralen, beside Zaki's Palace, Eguare, Uromi where the well water samples are collected were close to farmlands in which nitrogen based fertilizers were used for intense farming in the area, thereby leading to high NO_2 concentration in groundwater. When there is excessive rainfall nitrate will be leached below the plants roots zone and may eventually reach groundwater. Nitrate is highly leachable and readily moves with water through the soil profile. NO_2 in drinking water can be hazardous to health especially for infants (blue baby syndrome). Symptoms include shortness of breath and blueness of the skin.

Table 6: Lithology for Uje-Oro Street, Eguare, Uromi

Layer	Apparent Resistivity ρ_a (Ohm-m)	Thickness h (m)	Soil Lithology
1.	282	6.89	Top Soil
2.	8915	9.04	Sand
3.	789		Sand Stone

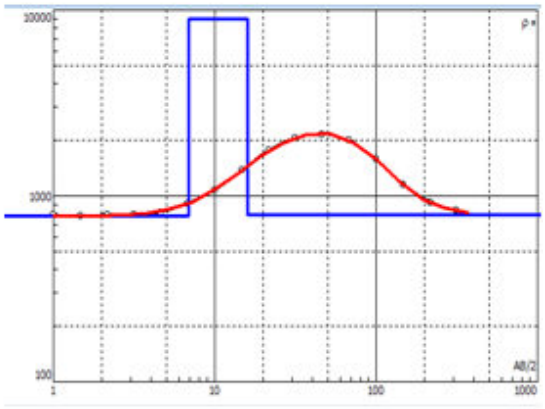

Fig 5: VES Curves and Layers Resistivity for Uje-Oro Street, Eguare

Total Depth = 15.93 meters

The sounding was done in Uje-Oro Street, Eguare, Uromi, with a GPS Co-ordinate of N06^0 43.005' E006^0 19.962'. The result shows a three-layer KQ-type geoelectric structure with top layer of resistivity 282 ohm-m, followed by the second and third layer of resistivity 8915 ohm-m and 789 ohm-m respectively. The first two layers of thickness 6.89m and 9.04m are top soil and sand respectively and the last layer is sand stone. The maximum depth of penetration is 15.93 meters. Water was not encountered in this location.

The physiochemical analyses of well water sample carried out in Uje-Oro Street, Eguare, Uromi, shows that the parameters analysed for groundwater is within the desirable limits set by the WHO standards of drinking water (see Table 1) except for pH (5.86) which is below the WHO standards of drinking water (6.5-8.5), therefore making the water acidic.

It is therefore suggested that sodium carbonate should be used as a purifier for groundwater that is acidic.

4.0 CONCLUSION

This paper has provided information on the depth to the groundwater and probably the thickness of the aquifer unit in the study area. The vertical electrical sounding (VES) has proven to be very reliable for underground water studies and therefore the method can excellently be used for shallow and deep underground water geophysical investigations. The results obtained show that Eguare (beside Zaki's Palace) with a maximum penetration of 69.01 meters, a perched aquifer was encountered, while aquifer was not encountered in Ivue (39.60 meters), Idumoza (37.01 meters), Egbele (92.60 meters) and Uje-Oro in Eguare (15.93 meters). The study area may hold good prospects for groundwater if very wide spread of current electrodes spacing is used thus going through a great depth to reach the water level. It was also observed that groundwater samples from hand dug wells in Ivue and Idumoza were within the WHO drinking water limits as at time of assessment while Egbele (3.20mg/L) and Eguare behind Zaki's Palace (4.44 mg/L) had high nitrate concentration and Uje-Oro in Eguare (5.86) had low pH value which were not within the ecological benchmark of the WHO drinking water standards. It was established that wells were polluted in areas nearer to farmlands than areas further away from them. The best way to generate continued supplies of clean groundwater is to reduce pollution. Therefore to mitigate the high level of Nitrate and pH concentration in boreholes and hand dug wells to fall within the acceptable limits of WHO drinking water standards, pH correction (addition of sodium carbonate) and boreholes / hand dug wells should be sited far away from the farm lands were Nitrogen based fertilizers are used and also sanitation units.

REFERENCE

Butcher H. L. M., (1982). Intelligence Reports in Ishan Division of Benin Province. Nigeria National Archives Ibadan. Pp. 240.

Dobrin, M. B, and King R. F (1976). Introduction to Geophysical prospecting. Mc Graw-Hill book, New York p. 630.

Koefoed, O (1979). Geosounding Principles, 1 (Resistivity Sounding Measurements). Elsevier Scientific Publishing Company Amsterdam – Oxford – New York. p. 230

Okhae, E. A (2005). The Distance Factor in Water Use for Domestic Purpose in Ekpoma Metropolis, Esan West

Local Government Area, Edo State. Unpublished M.Sc. Thesis, Ambrose Alli University, Ekpoma.
Okoduwa A. I., (2007). Geographical Factors in the Evolution of Esan Politics. Okoduwa A I (Ed.). Studies in Esan History and Cultures . Benin City Omo Uwessan Pub. 1.
Okojie C. G., (1994). Esan Native Laws and Customs with Ethnographic Studies of the Esan People. Benin Ilupeju Press, pp 2.
Omo-Ojugo M. O., (2004). Esan Language Endangered: Implications for the Teaching and Learning of Indigenous Languages in Nigeria (Inaugural lecture), Ambrose Alli University. pp 4
Osagie J. I., (2007). Economic Development in Esan in the Colonial Period. Nigeria Ph.D Thesis Department of History, University of Benin.
Osemeikhain, J. E, and Asokhia, M.B (1994) Applied Geophysics; Samtos Services ltd., Lagos, Nigeria.
Osibanjo, O. (1994). Present water quality status in Nigeria. Federal Environmental Protection Agency, Lagos. p. 20 – 23 .
Reinhard, K. F. (1974). Combined geo-electrical and Drill-hole investigation for detecting fresh-water aquifers in Northern western Missouri. Geophysics 39: p. 340 – 352.
Sandi M. and Darrin Q. (2007). Health Newsletter Archive.
WHO, (2006). Guidelines for drinking water quality, first addendum to 3rd edition, Vol. 1 Recommendations, Geneva.
World Resources, (1998). A guide to the Global Environment. (WR1, 1998,), Part 1; Environmental Change and Human Health. p. 386